

OPTIMIZING AIRPORT SURFACE OPERATIONS USING DATALINK AND THE TAXIWAY NAVIGATION AND SITUATION AWARENESS (T-NASA) DISPLAY SUITE

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Aircraft taxi operations have been shown to be inefficient and prone to high workload, radio frequency congestion, and communication errors (Kelley & Adam, 1997). Further, in low-visibility or night taxi conditions, taxi speeds decrease by approximately 20% and navigation errors increase leaving aircraft prone to traffic incursions (McCann, et al., 1998). To increase the efficiency and safety of surface operations, the Taxiway Navigation and Situation Awareness (T-NASA) cockpit display suite, comprised of an electronic moving map, a scene-linked head-up display, and 3-D audio alerts, was proposed (Foyle, et al., 1996). The T-NASA display suite has been subject to an extensive design and evaluation process (Andre, Hooley, Foyle, & McCann, 1998; McCann et al, 1998;), however, less is known about issues associated with the implementation of these displays into current and future taxi operations. This study set out to address several operational issues that were identified by pilots and controllers in a series of scenario-based focus groups (Hooley et al., 1999). These issues included the modality, timing, and presentation of taxi clearances and other surface related communications, and the ability for such a system to support time-sensitive and dynamic taxi operations.

PROCEDURE

Using NASA Ames high fidelity Advanced Concept Flight Simulator, 18 airline crews completed low visibility (RVR 1000) land-and-taxi scenarios. Crews taxied current day scenarios using standard operations and equipment (voice communications, ground clearances and Jeppesen chart for navigation) and future operations scenarios with either a Transition or Advanced equipment package (See Table 1). The Transition package, designed to integrate easily into current operations, provided ATC communications by both voice and datalink. The Advanced package, designed to accommodate an expected three-fold increase in airport traffic, provided ATC communications via datalink only, and included advanced features such as airborne taxi clearances.

Table 1. Experimental design

Group 1	Current Day Voice, Ground Clearance	Transition Operations Voice + Datalink, Ground Clearances	
	No T-NASA 4 scenarios	No T-NASA 5 scenarios	T-NASA 5 scenarios
Group 2	Current Day Voice, Ground Clearances	Advanced Operations Datalink only, Airborne Clearances	
	No T-NASA 4 scenarios	No T-NASA 5 scenarios	T-NASA 5 scenarios

RESULTS

The T-NASA display suite increased taxi speeds by 16% over current day scenarios ($M_{Current}=13.9$ kts, $M_{T-NASA}=16.1$ kts; $F(2,24) = 12.77$, $p<.0001$). Simultaneously, T-NASA eliminated major navigation errors (making a wrong turn or failing to turn) which occurred in 20% of the current day

scenarios. This provides strong evidence that T-NASA can increase taxi efficiency and safety.

Further benefits were observed with the Advanced equipment package which issued taxi clearances via datalink and T-NASA while airborne (just outside the outermarker). Currently, pilots stop after clearing the runway in order to receive and verify their taxi clearance. Airborne taxi clearances reduced time stopped after runway turnoff, $M_{Ground}=7.57$ sec, $M_{Airborne}= .02$ sec.; $t(8) = 2.47$, $p<.05$. Although airborne taxi clearances require a change to current day operating procedures, significant time savings may be realized.

Results also provided support for the use of datalink for routine surface operations communications. Issuing initial taxi clearances via datalink reduced workload, frequency congestion, and communication errors. However, one potential concern was revealed with the use of datalink to issue dynamic mid-route hold/proceed instructions. Datalink-only amendments (without T-NASA) increased the time required to initiate action of the taxi instruction; $M_{Current}=10.77$ sec., $M_{Datalink}=24.83$ sec.; $t(5)=-2.62$, $p<.05$. However, coupling datalink with T-NASA eliminated the excess delay and returned action initiation times to current day levels ($M_{datalink+T-NASA}= 9.58$ sec.). Datalink communications alone may create unnecessary delays but these delays may be ameliorated when datalink is coupled with T-NASA.

CONCLUSION

These results clearly demonstrate T-NASA's efficiency and safety benefits for surface operations. Also, taxi efficiency may be further increased by implementing changes to current operating procedures that include airborne taxi clearances and datalink communications. These efficiency gains also translate to reduced brake wear, reduced fuel burn, and faster turn around times of aircraft, which may provide substantial cost savings for airlines.

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